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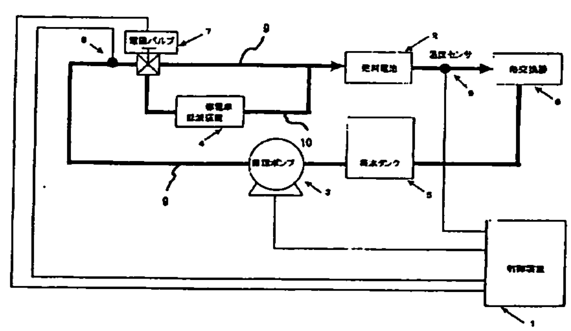
(54)【発明の名称】　燃料電池冷却液の導電率管理装置

(57)【要約】

【課題】　燃料電池冷却水の導電率を低減するために、冷却水を導電率低減装置へバイパスさせる構成を備えた燃料電池装置において、燃料電池の性能低下やポンプ負荷の増大を起こすことのないように冷却水導電率の管理を効率よく行う。

【解決手段】　循環ポンプ3により燃料電池2と熱交換器6とのあいだで冷却水を循環させる循環流路10と、この循環流路から取り出した冷却水を導電率低減装置4を通して循環流路に戻すバイパス流路11と、循環流路からバイパス流路への冷却水バイパス割合を調節するバルブ7と、冷却水の導電率を検出する導電率センサ8と、冷却水の導電率に基づいて前記バルブにより冷却水バイパス割合を制御する制御装置1と、冷却水の温度を検出する温度センサ9とを備える。冷却水の温度が基準温度以上かつ導電率が基準導電率以下のときには、前記導電率低減装置へのバイパス割合を減らすことにより、ポンプ負荷が大きい高温時には導電率低減装置への冷却水バイパスによる圧力損失を低減してポンプ負荷が過大となるのを防止する。



【特許請求の範囲】

【請求項１】循環ポンプにより燃料電池と熱交換器とのあいだで冷却液を循環させる循環系と、この循環系から取り出した冷却液を導電率低減装置を通して循環系に戻すバイパス系と、循環系からバイパス系への冷却液バイパス割合を調節するバルブと、冷却液の導電率を検出する導電率センサと、冷却液の導電率に基づいて前記バルブにより冷却液バイパス割合を制御する制御装置とを備えた燃料電池装置において、

冷却液の温度を検出する温度センサを設けると共に、

前記制御装置を、冷却液の温度が基準温度以上かつ導電率が基準導電率以下のときには、前記導電率低減装置へのバイパス割合を減らすように構成した燃料電池冷却液の導電率管理装置。

【請求項2】循環ポンプにより燃料電池と熱交換器とのあいだで冷却液を循環させる循環系と、この循環系から取り出した冷却液を導電率低減装置を通して循環系に戻すバイパス系と、循環系からバイパス系への冷却液バイパス割合を調節するバルブと、冷却液の導電率を検出する導電率センサと、冷却液の導電率に基づいて前記バルブにより冷却液バイパス割合を制御する制御装置とを備えた燃料電池装置において、

冷却液の温度を検出する温度センサを設けると共に、

前記制御装置を、冷却液の温度が基準温度以下かつ導電率が基準導電率以上のときには、前記導電率低減装置へのバイパス割合を増やすように構成した燃料電池冷却液の導電率管理装置。

【請求項3】循環ポンプにより燃料電池と熱交換器とのあいだで冷却液を循環させる循環系と、この循環系から取り出した冷却液を導電率低減装置を通して循環系に戻すバイパス系と、循環系からバイパス系への冷却液バイパス割合を調節するバルブと、冷却液の導電率を検出する導電率センサと、冷却液の導電率に基づいて前記バルブにより冷却液バイパス割合を制御する制御装置とを備えた燃料電池装置において、

循環ポンプの負荷を検出するポンプ負荷検出装置を設けると共に、

前記制御装置を、循環ポンプの負荷が基準負荷以上かつ導電率が基準導電率以下のときには、導電率低減装置へのバイパス割合を減らすように構成した燃料電池冷却液の導電率管理装置。

【請求項4】循環ポンプにより燃料電池と熱交換器とのあいだで冷却液を循環させる循環系と、この循環系から取り出した冷却液を導電率低減装置を通して循環系に戻すバイパス系と、循環系からバイパス系への冷却液バイパス割合を調節するバルブと、冷却液の導電率を検出する導電率センサと、冷却液の導電率に基づいて前記バルブにより冷却液バイパス割合を制御する制御装置とを備えた燃料電池装置において、

循環ポンプの負荷を検出するポンプ負荷検出装置を設けると共に、

前記制御装置を、循環ポンプの負荷が基準負荷以下かつ導電率が基準導電率以上のときには、導電率低減装置へのバイパス割合を増やすように構成した燃料電池冷却液の導電率管理装置。

【請求項5】前記制御装置を、検出した導電率が予め定めた上限基準値以上であるときには、冷却液の全量を導電率低減装置にバイパスさせるように構成した請求項１から請求項４の何れかに記載の燃料電池冷却液の導電率管理装置。

【請求項6】前記制御装置を、検出した導電率が燃料電池に応じて定めた許容限度値以上であるときには、燃料電池への燃料供給を停止すると共に循環ポンプの運転を停止するように構成した請求項１から請求項４の何れかに記載の燃料電池冷却液の導電率管理装置。

【請求項7】請求項１から請求項４の導電率管理装置において、導電率センサとして、導電率低減装置に流入する冷却液の導電率を検出する第１の導電率センサと、導電率低減装置から流出してきた冷却液の導電率を検出する第２の導電率センサとを設けると共に、前記第１の導電率センサの出力と第２の導電率センサの出力との差が判定基準値よりも小さいときに導電率低減装置の性能低下と判定する判定装置を備えた燃料電池冷却水の導電率管理装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は燃料電池冷却液の導電率管理装置に関する。

【０００２】

【従来の技術と解決すべき課題】固体高分子型燃料電池はその燃料となる水素あるいは水素リッチな改質ガスおよび空気を供給して電気化学反応を起こし電気エネルギを得ている。燃料電池システムには、このような化学反応で発熱した燃料電池を通常運転温度に維持するために冷却系統が設けられている。冷却系統は、冷却液を循環ポンプにより燃料電池へ供給し、燃料電池を通過した冷却液はラジエータのような熱交換器によって冷却した後にタンクに戻す循環系を構成している。冷却液としては一般に純度の高い純水が使用される。純水の導電率が増加すると燃料電池内でショートして発電量の低下さらには発電停止を起こすおそれを生じるので、純水の導電率を低減するためにイオン除去フィルタなどの導電率低減装置が設けられる。

【０００３】従来のフィルタを設けた循環システムとしては、特開平8-7912号公報に開示されているものが知られている。これは、水中の懸濁物濃度が許容上限濃度に達すると開閉弁を操作し、フィルタ側に水を流して懸濁物を除去するものである。また、イオン除去フィルタを設けて純水中の導電率を低減させるシステムとして、特開2000-208157号公報に開示されているものが知られて

いる。これは、メインの循環系とは別にサブの循環系を設け、サブの循環系にイオン除去フィルタを設けて導電率に応じてサブポンプの運転を制御し、純水の導電率を低減するものである。

【０００４】しかしながら、このように冷却水の懸濁物濃度に応じてフィルタへのバイパス量を決定するもの、あるいは純水の導電率によってバイパス量を決定するものでは、バイパス中のフィルタでの圧力損失が大きく、それだけ冷却水を循環させるポンプの負荷が増大してしまうという問題がある。燃料電池の運転状態によってさらに大きな冷却性能が要求された場合にはポンプの吐出能力を超えてしまい、燃料電池の冷却が不十分となって出力低下を余儀なくされることになる。あるいは、より大型のまたは多数のポンプが必要となり、電力消費量が大きくなり、システムとしての効率低下を招来する。

【０００５】本発明はこのような従来の問題点に着目してなされたもので、導電率低減装置による冷却液導電率の管理を効率よく行うことを目的としている。

【０００６】

【課題を解決するための手段】第１の発明は、循環ポンプにより燃料電池と熱交換器とのあいだで冷却液を循環させる循環系と、この循環系から取り出した冷却液を導電率低減装置を通して循環系に戻すバイパス系と、循環系からバイパス系への冷却液バイパス割合を調節するバルブと、冷却液の導電率を検出する導電率センサと、冷却液の導電率に基づいて前記バルブにより冷却液バイパス割合を制御する制御装置とを備えた燃料電池装置において、冷却液の温度を検出する温度センサを設けると共に、前記制御装置を、冷却液の温度が基準温度以上かつ導電率が基準導電率以下のときには、前記導電率低減装置へのバイパス割合を減らすように構成した。

【０００７】第２の発明は、循環ポンプにより燃料電池と熱交換器とのあいだで冷却液を循環させる循環系と、この循環系から取り出した冷却液を導電率低減装置を通して循環系に戻すバイパス系と、循環系からバイパス系への冷却液バイパス割合を調節するバルブと、冷却液の導電率を検出する導電率センサと、冷却液の導電率に基づいて前記バルブにより冷却液バイパス割合を制御する制御装置とを備えた燃料電池装置において、冷却液の温度を検出する温度センサを設けると共に、前記制御装置を、冷却液の温度が基準温度以下かつ導電率が基準導電率以上のときには、前記導電率低減装置へのバイパス割合を増やすように構成した。

【０００８】第３の発明は、循環ポンプにより燃料電池と熱交換器とのあいだで冷却液を循環させる循環系と、この循環系から取り出した冷却液を導電率低減装置を通して循環系に戻すバイパス系と、循環系からバイパス系への冷却液バイパス割合を調節するバルブと、冷却液の導電率を検出する導電率センサと、冷却液の導電率に基づいて前記バルブにより冷却液バイパス割合を制御する制御装置とを備えた燃料電池装置において、循環ポンプの負荷を検出するポンプ負荷検出装置を設けると共に、前記制御装置を、循環ポンプの負荷が基準負荷以上かつ導電率が基準導電率以下のときには、導電率低減装置へのバイパス割合を減らすように構成した。

【０００９】第４の発明は、循環ポンプにより燃料電池と熱交換器とのあいだで冷却液を循環させる循環系と、この循環系から取り出した冷却液を導電率低減装置を通して循環系に戻すバイパス系と、循環系からバイパス系への冷却液バイパス割合を調節するバルブと、冷却液の導電率を検出する導電率センサと、冷却液の導電率に基づいて前記バルブにより冷却液バイパス割合を制御する制御装置とを備えた燃料電池装置において、循環ポンプの負荷を検出するポンプ負荷検出装置を設けると共に、前記制御装置を、循環ポンプの負荷が基準負荷以下かつ導電率が基準導電率以上のときには、導電率低減装置へのバイパス割合を増やすように構成した。

【００１０】第５の発明は、前記各発明の制御装置を、検出した導電率が予め定めた上限基準値以上であるときには、冷却液の全量を導電率低減装置にバイパスさせるように構成した。

【００１１】第６の発明は、前記第１～第４の発明の制御装置を、検出した導電率が燃料電池に応じて定めた許容限度値以上であるときには、燃料電池への燃料供給を停止すると共に循環ポンプの運転を停止するように構成した。

【００１２】第７の発明は、前記第１～第４の発明において、導電率センサとして、導電率低減装置に流入する冷却液の導電率を検出する第１の導電率センサと、導電率低減装置から流出してきた冷却液の導電率を検出する第２の導電率センサとを設けると共に、前記第１の導電率センサの出力と第２の導電率センサの出力との差が判定基準値よりも小さいときに導電率低減装置の性能低下と判定する判定装置を備えた。

【００１３】

【作用・効果】第１の発明では、冷却液の温度が高く、導電率が低いときには導電率低減装置への冷却液バイパス割合を減らす。高い冷却性能が要求される高温時にはバイパス流量を減らして冷却を優先させるのであり、これにより導電率低減装置での圧力損失を低減してそれだけ循環ポンプの負荷を軽減することができる。したがって循環ポンプの小型化を図り、あるいは冷却性能の向上による燃料電池の運転効率改善を図ることができる。

【００１４】第２の発明では、冷却液の温度が低く、導電率が高いときには導電率低減装置へのバイパス割合を増やす。放熱量が少ない低温時に冷却液の導電率低減を優先させるのであり、これにより循環ポンプの負荷を軽減することができる。

【００１５】第３の発明では、循環ポンプの負荷が高く、導電率が低いときには導電率低減装置へのバイパス

割合を減らす。冷却のために循環ポンプの負荷が高いときには導電率低減装置へのバイパス量を減じるのであり、これにより導電率低減装置での圧力損失によりポンプ負荷が過大となるのを防止することができる。

【００１６】第４の発明では、循環ポンプの負荷が低く、導電率が高いときには導電率低減装置へのバイパス割合を増やす。、冷却のための循環ポンプの負荷が低いときに冷却液の導電率低減を優先して行うのであり、これによりポンプ負荷が過大となるのを防止することができる。

【００１７】第５の発明では、導電率センサの信号が上限基準値を超えた場合、冷却液の温度、循環ポンプの負荷にかかわらず冷却液の全量を導電率低減装置にバイパスすることで冷却液の導電率を可能な限り低下させる。これにより、燃料電池に導電率が高い冷却液が供給されることに原因する出力低下等の問題を回避することができる。

【００１８】第６の発明では、冷却液の導電率が燃料電池の許容限度値を超えた場合、冷却液の供給を止めて、燃料電池の発電を停止させる。これにより、燃料電池システムの故障を未然に防ぐことができる。

【００１９】第７の発明によれば、導電率低減装置の入口側に設けた第１の導電率センサと、出口側に設けた第２の導電率センサとの出力差に基づき、もし下流側の導電率が低下していなければ導電率低減装置によって導電性イオンが除去されていないことがわかるので、導電率低減装置の性能低下を判定して警告を発し、あるいは導電率低減装置の交換時期を明示する等の的確な維持管理が可能となる。

【００２０】

【発明の実施の形態】以下本発明の実施形態を図面に基づいて説明する。図１において、１はマイクロコンピュータおよびその周辺装置等から構成される制御装置、２は電気化学反応により起電力を得る燃料電池、３は冷却液として純水を供給する電動式の循環ポンプ、４は冷却水（純水）の導電率を低減する導電率低減装置、５は冷却水を一時的に貯蔵するタンク、６は冷却水を冷却する熱交換器、７は冷却水の流路を切り替える電磁バルブ、８は冷却水の導電率を検知する導電率センサ、９は冷却水の温度を検知する温度センサである。１０は前記タンク６の冷却水を燃料電池２と熱交換器６との間で循環させる循環流路（循環系）、１１は循環流路１０の途中から前記電磁バルブ７の開度に応じて分流させた冷却水を導電率低減装置４を通して再び循環流路１０に戻すバイパス流路（バイパス系）である。

【００２１】循環ポンプ３は吐出量の要求に応じて回転数が可変制御される構成であり、制御装置１はその回転数の指令値を燃料電池２の運転状態や冷却水温度に応じて決定し、循環ポンプ３の駆動を制御する。燃料電池は水素と酸素の化学反応により電力を発生する。前記循環ポンプ３や各種電気機器の電源としては前記燃料電池２の起電力があてられる。

【００２２】化学反応に伴う燃料電池２の温度上昇を抑制するために冷却水を循環ポンプ３により熱交換器６とのあいだで循環させる。燃料電池２に供給する冷却水は、燃料電池内でのショートにより発電量が低下することを防止するために導電率が低く抑えられていなければならない。自動車等の移動体に搭載するような循環システムでは、外部の純水製造装置から導電率の低い冷却水を供給することができないため、冷却水の導電率を低く維持することは重要である。しかしながら導電性イオンが配管や熱交換器など純水が金属と接触する部分から溶け出すことから、そのまま放置すれば導電率は経時的に上昇してゆく。導電率低減装置４はこの溶け出した導電性イオンを除去する機能を有している。

【００２３】導電率低減装置は、例えば図2に示すようにイオン交換樹脂１２が充填されたフィルタ構造になっており、冷却水を通過させることにより導電性イオンを除去し、導電率を低下させるものである。このような導電率低減装置４は、フィルタに純水を通過させる構造上、圧力損失が発生する。イオン交換樹脂の充填量が多ければイオン除去性能は向上するが圧力損失は増してしまう。そこで、導電率低減装置４は圧力損失の影響を抑えるために、循環流路１０とは別に設けたバイパス流路１１に介装し、必要限度で冷却水を通過させるようにしている。

【００２４】バイパス流路１１への流量を切り替える電磁バルブ７は、制御装置１からの信号によって開度が連続的または多段階的に可変制御される三方弁であり、循環流路１０全開－バイパス流路１１全閉の状態から、その逆の状態まで制御装置１からの信号を受け、2つの流路１０または１１への純水量を調節する。

【００２５】冷却水の導電率の検出は、純水中の電気抵抗を測定する原理による導電率センサ８を介して行われる。導電率センサ８は、導電率に応じた信号を制御装置１に送出する。導電率は温度によって変化するので、例えば２５℃に換算した導電率が適用される。制御装置１は、図３に示すように導電率センサ８から得られる冷却水の導電率に基づいて電磁バルブ７への指令値を演算し、循環流路１０からバイパス流路１１にバイパスさせる冷却水流量の割合を決定している。

【００２６】燃料電池２を冷却して温度が上昇した冷却水は、燃料電池２の下流に設けられた熱交換器６で放熱したのちタンク５に戻される。循環経路１０内の冷却水の温度は温度センサ９で検出され、この検出信号は制御装置１に送出される。燃料電池温度と冷却水温度は相関関係があり、図4に示すように始動時は外気温相当だが、発電とともに徐々に上昇する。定常では一定温度を保つが、高出力発電時や過渡時にはこの限りではない。

【００２７】冷却水温度を充分に低下させるには熱交換

器６に多量の冷却水を送り込む必要があり循環ポンプ３の負荷はそれだけ大きなものとなる。その反対に、冷却水の冷却を必要としない低水温時は低吐出流量で済むためポンプ負荷は低い。このように冷却水温度とポンプ負荷は相関があり、ポンプ能力が不足すれば冷却水温度を低下させることができない。大型のポンプを使いポンプ能力を上げることは、外部電源によるポンプ駆動が不可能かつ、搭載に制約の多い移動体用の燃料電池システムにおいては好ましくない。

【００２８】そこで本実施形態では、冷却水の導電率に応じて決定した導電率低減装置４へのバイパス流量に、冷却水の温度による補正を加えて最適化を図ることで、限られたポンプ能力の範囲内で冷却要求と導電率低減要求とを両立させ得るようにしている。具体的には、図５に示すように、ポンプ負荷の大きい高水温時には導電率低減装置４への冷却水バイパス割合を減らすことによりフィルタ部での圧力損失を極力なくしてポンプ負荷を軽減させ、冷却水の冷却を優先させる。また、ポンプ負荷の少ない低水温時には、導電率低減装置４へのバイパス割合を増やし、純水のイオン濃度を低減させるのである。これにより、循環ポンプ３の小型化、省電力化ができるばかりでなく、燃料電池２の性能向上、熱交換器６を含めた冷却システムの低価格化、および導電率低減装置４の最適設計を図ることが可能となる。

【００２９】導電率低減装置４への冷却水バイパス割合の制御に関する第２の実施形態として、冷却水の導電率に応じて決定した導電率低減装置４への冷却水バイパス割合を、循環ポンプ３の負荷に応じて補正するようにしてもよい。図6に示すように、循環ポンプ３の負荷はその回転数と相関があるため、循環ポンプ３の回転数から負荷状態を判定することができる。このポンプ負荷が大きいときにはバイパス割合を減らし、ポンプ負荷の小さいときにはバイパス割合が増えるように制御するのである。これによりポンプ負荷の少ないときに冷却水の導電率低減処理を行うので、循環ポンプ３の要求最大負荷を抑えてその小型化を図ることができる。

【００３０】ところで、冷却水の冷却を優先させて導電率低減装置４へのバイパス量を低減させていると、燃料電池２の運転状態や環境条件によっては、いずれは燃料電池２が許容しない導電率に達して、発電量の低下によって走行性能の低下や燃料電池２の故障を招くおそれがある。そこで、図7に示すように、導電率が予め定めた上限値を超えた場合、冷却水温度やポンプ負荷にかかわらず電磁バルブ７を操作して全ての冷却水を導電率低減装置４へバイパスさせることにより、導電率の低減を優先させるように図るとよい。さらには、図8に示すように、導電率の低下を防ぐことができず、燃料電池２の許容範囲を超えて導電率が上昇してしまった場合には、燃料電池２による発電を停止すると共に、循環ポンプ３を停止させて燃料電池２への冷却水の供給を止めるようにするのがなお望ましい。

【００３１】図９に導電率低減装置４の劣化を判定するようにした実施形態を示す。導電率低減装置４は前述したようにイオン交換樹脂が充填されたフィルタ構造になっている。イオン交換樹脂は化学的に導電性イオンを吸着するしくみになっているためその吸着量には限界があり、定期的な交換が必要である。イオン交換樹脂の性能低下は外観で判断することは困難であるので、従来は一定期間毎に交換を行うものとしていた。しかし、交換時期は時間ではなく本来はイオンの吸着限界によるべきものであるので、最適な交換時期を見出すのは困難であった。

【００３２】そこでこの実施形態では、図9に示すように、導電率低減装置４通過前の冷却水の導電率を第1の導電率センサ８Ａにより測定すると共に、導電率低減装置４を通過した冷却水の導電率を第2の導電率センサ８Ｂにより測定する。図９のその他の部分の構成は図１と同一であり、同一の部分には同一の符号を付して示してある。

【００３３】導電率低減装置４が正常に機能している場合、通過した冷却水の導電率は低下しているはずである。これに対して、もしも導電率低減装置４を通過したのちにも導電率が低下していなければ導電率低減装置４が正常に機能していないことになる。すなわち第１のセンサ８Ａによる測定値よりも第２のセンサ８Ｂによる測定値は低下しているはずである。このようにして、第1の導電率センサ８Ａの信号と第2の導電率センサ８Ｂの信号を比較して導電率の低下幅を検知することにより導電率低減装置４の性能低下を判断することができる。このときの判断基準となる導電率の低下幅は、第１のセンサ８Ａによる導電率が高いときほど大きく、低いときほど小さくするとよい。冷却水の導電率が低いときにはイオン交換樹脂による吸着効率も低下するからである。

【００３４】このようにして導電率低減装置４の劣化判定を行い、もし劣化と判断したときには制御装置１により傾向を発してイオン交換樹脂の交換を促すようにすれば、導電率低減装置４の機能を常時正常に保ち、燃料電池冷却水の導電率をより適切に管理することができる。

【図面の簡単な説明】

【図１】本発明を適用した燃料電池装置の実施形態の概略構成図。

【図２】導電率低減装置の概略構成図。

【図３】導電率と導電率低減装置への冷却水バイパス割合との関係を示す特性図。

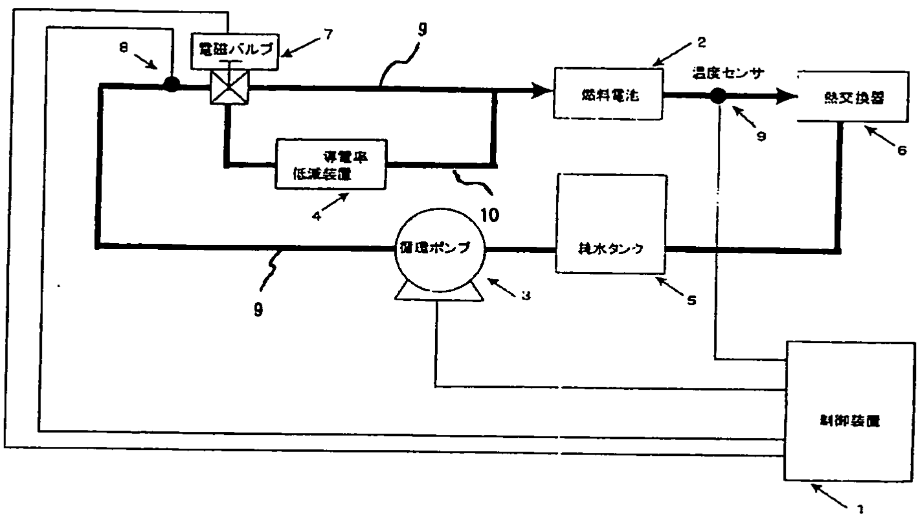
【図４】燃料電池の使用状態と冷却水温度との関係を示す特性図。

【図５】冷却水温度に応じた導電率と導電率低減装置への冷却水バイパス割合との関係を示す特性図。

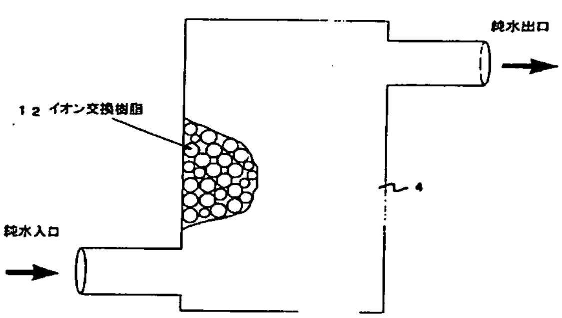
【図６】循環ポンプの回転数と負荷との関係を示す特性図。

【図７】導電率の上限値に関する特性図。
【図８】導電率の許容値に関する特性図。
【図９】本発明を適用した燃料電池装置の他の実施形態の概略構成図。
【符号の説明】
1　制御装置
2　燃料電池
3　循環ポンプ
4　導電率低減装置
5　タンク
6　熱交換器
7　電磁バルブ
8　導電率センサ
8ａ　導電率センサ
8ｂ　導電率センサ
9　温度センサ
10　循環流路
11　バイパス流路
12　イオン交換樹脂

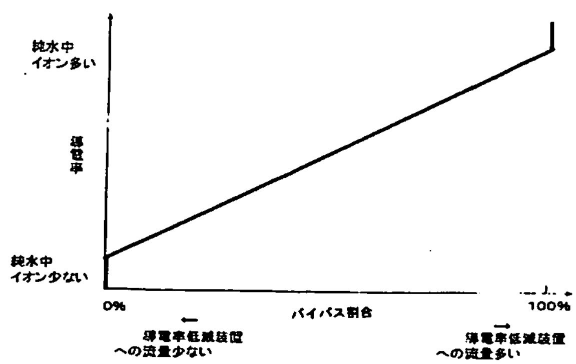
【図１】



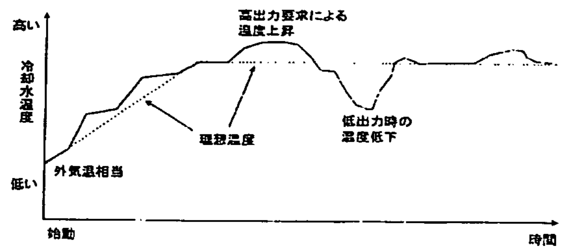
【図２】



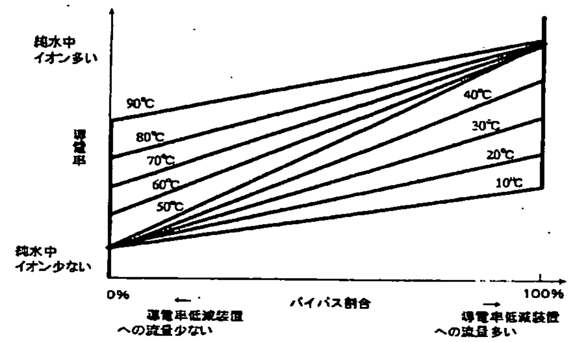
【図３】



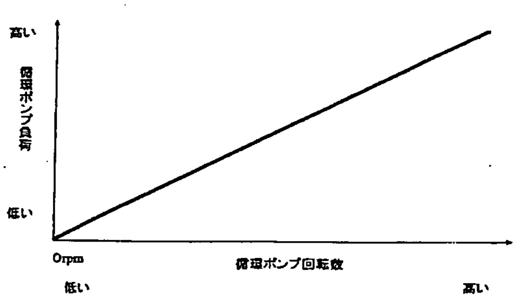
【図４】


高い
冷却水温度
低い
高出力要求による
温度上昇
理想温度
低出力時の
温度低下
外気温相当
始動
時間

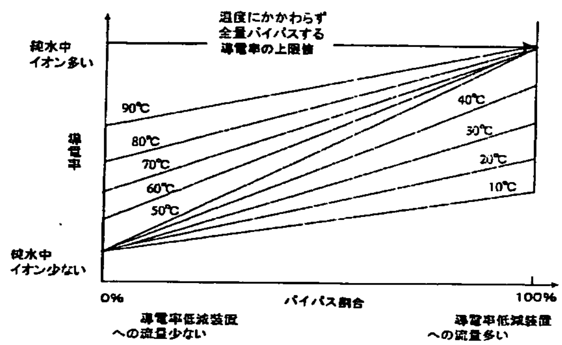
【図５】


純水中
イオン多い
導電率
純水中
イオン少ない
90℃
80℃
70℃
60℃
50℃
40℃
30℃
20℃
10℃
0%
バイパス割合
100%
導電率低減装置
への流量少ない
導電率低減装置
への流量多い

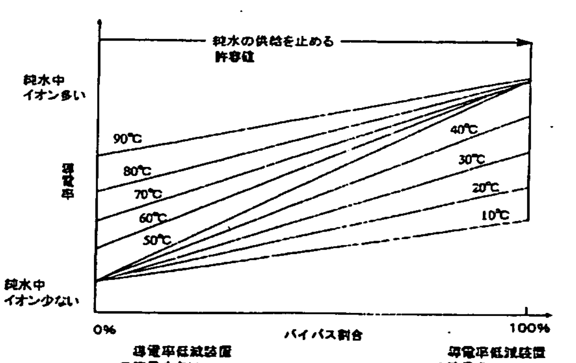
【図６】


高い
循環ポンプ負荷
低い
0rpm
低い
循環ポンプ回転数
高い

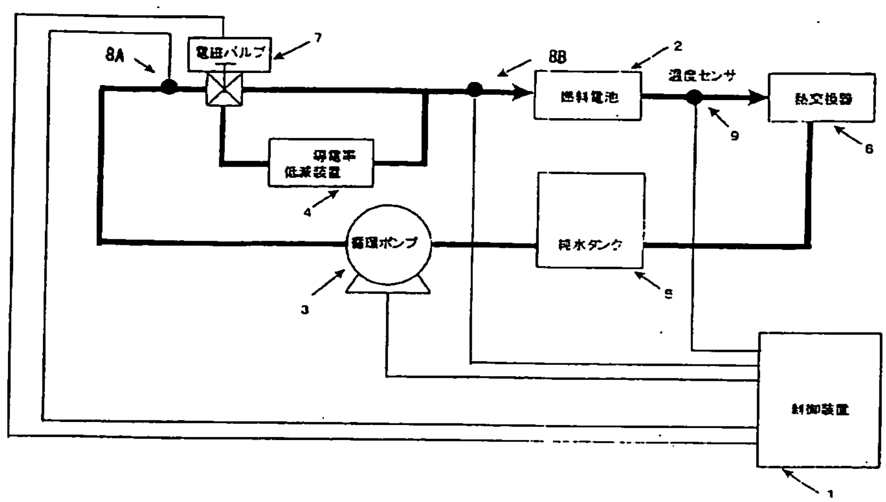
【図７】


温度にかかわらず
全量バイパスする
導電率の上限値
純水中
イオン多い
導電率
純水中
イオン少ない
90℃
80℃
70℃
60℃
50℃
40℃
30℃
20℃
10℃
0%
バイパス割合
100%
導電率低減装置
への流量少ない
導電率低減装置
への流量多い

【図８】


純水の供給を止める
許容値
純水中
イオン多い
導電率
純水中
イオン少ない
90℃
80℃
70℃
60℃
50℃
40℃
30℃
20℃
10℃
0%
バイパス割合
100%
導電率低減装置
への流量少ない
導電率低減装置
への流量多い

【図９】


電磁バルブ
7
8A
8B
2
燃料電池
温度センサ
熱交換器
9
6
導電率
低減装置
4
循環ポンプ
3
純水タンク
5
制御装置
1

PATENT ABSTRACTS OF JAPAN

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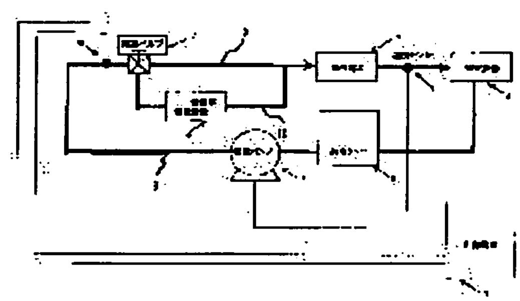
(22)Date of filing : 24.01.2001

(71)Applicant : NISSAN MOTOR CO LTD
(72)Inventor : KASHIWAGI NAOTO

(54) CONDUCTIVITY CONTROL DEVICE FOR FUEL CELL COOLING LIQUID

(57)Abstract:
PROBLEM TO BE SOLVED: To efficiently control conductivity of coolant liquid so as not to cause performance degradation of a fuel battery or increase of pump load in case of a fuel cell device equipped with a structure of bypassing coolant water to a conductivity-lowering device in order to lower conductivity of the fuel cell coolant water.



SOLUTION: The conductivity control device is provided with a circulating flow channel 10 circulating coolant water between a fuel cell 2 and a heat exchanger 6 with a circulating pump 3, a bypass flow channel 11 for returning coolant water drawn out of the circulating flow channel back to the circulating flow channel through a conductivity-lowering device 4, a valve 7 for adjusting bypassing ratio of coolant water from the circulating flow channel to the bypass flow channel, a conductivity sensor 8 detecting conductivity of coolant water, a control device 1 for controlling bypassing ratio of coolant water by the valve according to conductivity of coolant water, and a temperature sensor 9 detecting temperature of coolant water. When the temperature of coolant water is above a standard temperature and conductivity below a standard conductivity, bypassing ratio to the conductivity-lowering device is reduced, whereby, pump load is prevented from becoming excessively high by lowering pressure loss due to coolant water bypass to the conductivity-lowering device, at time of high temperature when pump load is high.

LEGAL STATUS

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[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3659173
[Date of registration]	25.03.2005
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

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CLAIMS

[Claim(s)]
[Claim 1] The circulatory system which circulates the coolant between a fuel cell and a heat exchanger with a circulating pump, The bypass system which returns the coolant taken out from this circulatory system to the circulatory system through conductivity reduction equipment, The bulb which adjusts the coolant bypass rate from the circulatory system to a bypass system, While forming the temperature sensor which detects the temperature of the coolant in fuel cell equipment equipped with the conductivity sensor which detects the conductivity of the coolant, and the control unit which controls a coolant bypass rate by said bulb based on the conductivity of the coolant Conductivity management equipment of the fuel cell coolant which more than a base temperature and conductivity constituted so that the bypass rate to said conductivity reduction equipment might be reduced when the temperature of the coolant was below criteria conductivity about said control unit.
[Claim 2] The circulatory system which circulates the coolant between a fuel cell and a heat exchanger with a circulating pump, The bypass system which returns the coolant taken out from this circulatory system to the circulatory system through conductivity reduction equipment, The bulb which adjusts the coolant bypass rate from the circulatory system to a bypass system, While forming the temperature sensor which detects the temperature of the coolant in fuel cell equipment equipped with the conductivity sensor which detects the conductivity of the coolant, and the control unit which controls a coolant bypass rate by said bulb based on the conductivity of the coolant Conductivity management equipment of the fuel cell coolant which below a base temperature and conductivity constituted so that the bypass rate to said conductivity reduction equipment might be increased when the temperature of the coolant was more than criteria conductivity about said control unit.
[Claim 3] The circulatory system which circulates the coolant between a fuel cell and a heat exchanger with a circulating pump, The bypass system which returns the coolant taken out from this circulatory system to the circulatory system through conductivity reduction equipment, The bulb which adjusts the coolant bypass rate from the circulatory system to a bypass system, In fuel cell equipment equipped with the conductivity sensor which detects the conductivity of the coolant, and the control unit which controls a coolant bypass rate by said bulb based on the conductivity of the coolant Conductivity management equipment of the fuel cell coolant which more than a criteria load and conductivity constituted so that the bypass rate to conductivity reduction equipment might be reduced when the load of a circulating pump was below criteria conductivity about said control unit while forming the pump load detection equipment which detects the load of a circulating pump.
[Claim 4] The circulatory system which circulates the coolant between a fuel cell and a heat exchanger with a circulating pump, The bypass system which returns the coolant taken out from this circulatory system to the circulatory system through conductivity reduction equipment, The bulb which adjusts the coolant bypass rate from the circulatory system to a bypass system, In fuel cell equipment equipped with the conductivity sensor which detects the conductivity of the coolant, and the control unit which controls a coolant bypass rate by said bulb based on the conductivity of the coolant Conductivity management equipment of the fuel cell coolant which below a criteria load and conductivity constituted so that the bypass rate to conductivity reduction equipment might be increased when the load of a circulating pump was more than criteria conductivity about said control unit while forming the pump load detection equipment which detects the load of a circulating pump.
[Claim 5] Conductivity management equipment of the fuel cell coolant given in any of claim 1 to

claim 4 constituted so that conductivity reduction equipment might be made to bypass the whole quantity of the coolant when it is beyond the upper limit reference value with which the detected conductivity defined said control unit beforehand, they are.

[Claim 6] Conductivity management equipment of the fuel cell coolant given in any of claim 1 to claim 4 constituted so that operation of a circulating pump might be suspended while suspending the fuel supply to a fuel cell when it is beyond the tolerance limit value as which the detected conductivity determined said control unit according to the fuel cell they are.

[Claim 7] In the conductivity management equipment of claim 1 to claim 4 as a conductivity sensor While forming the 1st conductivity sensor which detects the conductivity of the coolant which flows into conductivity reduction equipment, and the 2nd conductivity sensor which detects the conductivity of the coolant which has flowed out of conductivity reduction equipment Conductivity management equipment of fuel cell cooling water equipped with the judgment equipment judged to be the degradation of conductivity reduction equipment when the difference of the output of said 1st conductivity sensor and the output of the 2nd conductivity sensor is smaller than a criterion value.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the conductivity management equipment of the fuel cell coolant.
[0002]
[Description of the Prior Art] the hydrogen from which a polymer electrolyte fuel cell serves as the fuel, or hydrogen -- rich reformed gas and air were supplied and electrochemical reaction has been acquired for lifting electrical energy. In order to usually maintain the fuel cell which generated heat by such chemical reaction to an operating temperature, the cooling system is formed in the fuel cell system. A cooling system supplies the coolant to a fuel cell with a circulating pump, and the coolant which passed the fuel cell constitutes the circulatory system returned to a tank, after cooling by heat exchanger like a radiator. Generally as coolant, pure water with high purity is used. Since a possibility of short-circuiting within a fuel cell and causing a generation-of-electrical-energy halt to the fall pan of the amount of generations of electrical energy will be produced if the conductivity of pure water increases, in order to reduce the conductivity of pure water, conductivity reduction equipments, such as a deionizer filter, are formed.
[0003] What is indicated by JP,8-7912,A is known as a circulation system which prepared the conventional filter. This will operate a closing motion valve, if underwater suspended solid concentration reaches permissible upper limit concentration, to a filter side, pours water and removes a suspended solid. Moreover, what is indicated by JP,2000-208157,A is known as a system which a deionizer filter is prepared [system] and reduces the conductivity in pure water. The circulatory system of Maine establishes a factice's circulatory system independently, prepares a deionizer filter in a factice's circulatory system, and controls operation of a subpump according to conductivity, and this reduces the conductivity of pure water.
[0004] However, in the thing which determines the by-pass rate of FIRUTAHE according to the suspended solid concentration of cooling water in this way, or the thing which determines a by-pass rate with the conductivity of pure water, the pressure loss in the filter in a bypass is large, and there is a problem that the load of the pump made to circulate through cooling water so much will increase. When the still bigger cooling engine performance is required according to the operational status of a fuel cell, the regurgitation capacity of a pump will be exceeded, cooling [of a fuel cell] will become inadequate, and it will be obliged to loss of power. Or the pump of a large mold or a large number is more needed, power consumption becomes large, and the degradation as a system is invited.
[0005] This invention was made paying attention to such a conventional trouble, and aims at managing the coolant conductivity by conductivity reduction equipment efficiently.
[0006]
[Means for Solving the Problem] The circulatory system which the 1st invention makes circulate through the coolant between a fuel cell and a heat exchanger with a circulating pump, The bypass system which returns the coolant taken out from this circulatory system to the circulatory system through conductivity reduction equipment, The bulb which adjusts the coolant bypass rate from the circulatory system to a bypass system, While forming the temperature sensor which detects the temperature of the coolant in fuel cell equipment equipped with the conductivity sensor which

detects the conductivity of the coolant, and the control unit which controls a coolant bypass rate by said bulb based on the conductivity of the coolant When the temperature of the coolant was below criteria conductivity about said control unit, more than a base temperature and conductivity constituted so that the bypass rate to said conductivity reduction equipment might be reduced.
[0007] The circulatory system which the 2nd invention makes circulate through the coolant between a fuel cell and a heat exchanger with a circulating pump, The bypass system which returns the coolant taken out from this circulatory system to the circulatory system through conductivity reduction equipment, The bulb which adjusts the coolant bypass rate from the circulatory system to a bypass system, While forming the temperature sensor which detects the temperature of the coolant in fuel cell equipment equipped with the conductivity sensor which detects the conductivity of the coolant, and the control unit which controls a coolant bypass rate by said bulb based on the conductivity of the coolant When the temperature of the coolant was more than criteria conductivity about said control unit, below a base temperature and conductivity constituted so that the bypass rate to said conductivity reduction equipment might be increased.
[0008] The circulatory system which the 3rd invention makes circulate through the coolant between a fuel cell and a heat exchanger with a circulating pump, The bypass system which returns the coolant taken out from this circulatory system to the circulatory system through conductivity reduction equipment, The bulb which adjusts the coolant bypass rate from the circulatory system to a bypass system, In fuel cell equipment equipped with the conductivity sensor which detects the conductivity of the coolant, and the control unit which controls a coolant bypass rate by said bulb based on the conductivity of the coolant While forming the pump load detection equipment which detects the load of a circulating pump, more than a criteria load and conductivity constituted so that the bypass rate to conductivity reduction equipment might be reduced, when the load of a circulating pump was below criteria conductivity about said control unit.
[0009] The circulatory system which the 4th invention makes circulate through the coolant between a fuel cell and a heat exchanger with a circulating pump, The bypass system which returns the coolant taken out from this circulatory system to the circulatory system through conductivity reduction equipment, The bulb which adjusts the coolant bypass rate from the circulatory system to a bypass system, In fuel cell equipment equipped with the conductivity sensor which detects the conductivity of the coolant, and the control unit which controls a coolant bypass rate by said bulb based on the conductivity of the coolant While forming the pump load detection equipment which detects the load of a circulating pump, below a criteria load and conductivity constituted so that the bypass rate to conductivity reduction equipment might be increased, when the load of a circulating pump was more than criteria conductivity about said control unit.
[0010] When it was beyond the upper limit reference value with which the detected conductivity defined the control unit of said invention of each beforehand, the 5th invention was constituted so that conductivity reduction equipment might be made to bypass the whole quantity of the coolant.
[0011] When it was beyond the tolerance limit value as which the detected conductivity determined said control unit of the 1st - the 4th invention according to the fuel cell, the 6th invention was constituted so that operation of a circulating pump might be suspended, while suspending the fuel supply to a fuel cell.
[0012] The 7th invention is set to said 1st [the] - the 4th invention. As a conductivity sensor While forming the 1st conductivity sensor which detects the conductivity of the coolant which flows into conductivity reduction equipment, and the 2nd conductivity sensor which detects the conductivity of the coolant which has flowed out of conductivity reduction equipment When the difference of the output of said 1st conductivity sensor and the output of the 2nd conductivity sensor was smaller than a criterion value, it had judgment equipment judged to be the degradation of conductivity reduction equipment.
[0013]
[Function and Effect] In the 1st invention, the temperature of the coolant is high, and when conductivity is low, the coolant bypass rate to conductivity reduction equipment is reduced. A bypass flow rate can be reduced at the time of the elevated temperature as which the high cooling engine performance is required, priority can be given to cooling, the pressure loss in conductivity reduction equipment can be reduced by this, and the load of a circulating pump can be mitigated so

much. Therefore, the miniaturization of a circulating pump can be attained or operation improvement in efficiency of the fuel cell by improvement in the cooling engine performance can be aimed at.
[0014] the 2nd invention -- the temperature of the coolant -- low -- < -- when conductivity is high, the bypass rate to conductivity reduction equipment is increased. Priority can be given to conductivity reduction of the coolant at the time of low temperature with little heat release, and, thereby, the load of a circulating pump can be mitigated.
[0015] In the 3rd invention, the load of a circulating pump is expensive, and when conductivity is low, the bypass rate to conductivity reduction equipment is reduced. For cooling, when the load of a circulating pump is expensive, the by-pass rate to conductivity reduction equipment can be reduced, and it can prevent that a pump load becomes excessive by the pressure loss in conductivity reduction equipment by this.
[0016] In the 4th invention, it is low, and the load of a circulating pump increases the bypass rate to conductivity reduction equipment, when conductivity is high. When the load of the circulating pump for cooling is low, it can carry out by the ability giving priority to conductivity reduction of the coolant, and it can prevent that a pump load becomes excessive by this.
[0017] By 5th invention, when the signal of a conductivity sensor exceeds an upper limit reference value, the conductivity of the coolant is reduced as much as possible by bypassing the whole quantity of the coolant to conductivity reduction equipment irrespective of the temperature of the coolant, and the load of a circulating pump. Problems, such as loss of power which results from the coolant with high conductivity being supplied to a fuel cell by this, are avoidable.
[0018] In the 6th invention, when the conductivity of the coolant exceeds the tolerance limit value of a fuel cell, supply of the coolant is stopped and a generation of electrical energy of a fuel cell is stopped. Thereby, failure of a fuel cell system can be prevented.
[0019] Since it turns out that conductive ion is not removed by conductivity reduction equipment based on the output difference of the 1st conductivity sensor prepared in the entrance side of conductivity reduction equipment, and the 2nd conductivity sensor prepared in the outlet side according to the 7th invention if the conductivity of the downstream is not falling, the degradation of conductivity reduction equipment is judged, and warning emits, or the exact maintenance of specifying the exchange stage of conductivity reduction equipment becomes possible.
[0020]
[Embodiment of the Invention] The operation gestalt of this invention is explained based on a drawing below. The control unit with which 1 consists of a microcomputer, its peripheral device, etc. in drawing 1 , The fuel cell from which 2 acquires electromotive force according to electrochemical reaction, the electromotive circulating pump with which 3 supplies pure water as coolant, The conductivity reduction equipment with which 4 reduces the conductivity of cooling water (pure water), the tank by which 5 stores cooling water temporarily, The heat exchanger to which 6 cools cooling water, the electro-magnetic valve with which 7 changes the passage of cooling water, the conductivity sensor by which 8 detects the conductivity of cooling water, and 9 are temperature sensors which detect the temperature of cooling water. The circulating flow way (circulatory system) which 10 makes circulate through the cooling water of said tank 6 between a fuel cell 2 and a heat exchanger 6, and 11 are bypass passage (bypass system) which returns again the cooling water made to shunt according to the opening of said electro-magnetic valve 7 from the middle of the circulating flow way 10 to the circulating flow way 10 through conductivity reduction equipment 4.
[0021] A circulating pump 3 is the configuration that adjustable control of the rotational frequency is carried out according to the demand of discharge quantity, and a control unit 1 determines the command value of the rotational frequency according to the operational status and the circulating water temperature of a fuel cell 2, and controls the drive of a circulating pump 3. A fuel cell generates power by the chemical reaction of hydrogen and oxygen. As a power source of said circulating pump 3 and various electrical machinery and apparatus, the electromotive force of said fuel cell 2 is guessed.
[0022] In order to control the temperature rise of the fuel cell 2 accompanying a chemical reaction, cooling water is circulated between heat exchangers 6 with a circulating pump 3. In order that the cooling water supplied to a fuel cell 2 may prevent the thing within a fuel cell which the amount of generations of electrical energy falls more short, conductivity must be stopped low. In a circulation

system which is carried in mobiles, such as an automobile, since cooling water with low conductivity cannot be supplied from an external water purifying apparatus, it is important to maintain the conductivity of cooling water low. However, from conductive ion beginning to melt from the part to which pure water, such as piping and a heat exchanger, contacts a metal, if it is left as it is, conductivity will rise with time. Conductivity reduction equipment 4 has the function to remove this conductive ion that began to melt.

[0023] Conductivity reduction equipment has the filter structure where it filled up with ion exchange resin 12, as shown in drawing 2, by passing cooling water, removes conductive ion and reduces conductivity. Pressure loss generates such conductivity reduction equipment 4 on the structure of making a filter passing pure water. If there are many fills of ion exchange resin, although the deionizer engine performance will improve, pressure loss will increase. Then, in order to suppress the effect of pressure loss, he infixes conductivity reduction equipment 4 in the bypass passage 11 prepared independently [the circulating flow way 10], and is trying to pass cooling water in a need limit.

[0024] With the signal from a control unit 1, opening is the cross valve by which adjustable control is carried out continuously or in multistage story, and the electro-magnetic valve 7 which changes the flow rate to the bypass passage 11 receives the signal from a control unit 1 from the condition of circulating flow way 10 full-open-bypass passage 11 close by-pass bulb completely to the reverse condition, and adjusts the amount of pure water to two passage 10 or 11.

[0025] Detection of the conductivity of cooling water is performed through the conductivity sensor 8 by the principle which measures the electric resistance in pure water. The conductivity sensor 8 sends out the signal according to conductivity to a control unit 1. Since conductivity changes with temperature, the conductivity converted into 25 degrees C, for example is applied. The control unit 1 calculated the command value of electro-magnetic valve 7 HE based on the conductivity of the cooling water obtained from the conductivity sensor 8, as shown in drawing 3 , and it has determined the rate of the cooling water flow rate which the bypass passage 11 is made to bypass from the circulating flow way 10.

[0026] After the cooling water with which the fuel cell 2 was cooled and temperature rose radiates heat by the heat exchanger 6 prepared in the lower stream of a river of a fuel cell 2, it is returned to a tank 5. The temperature of the cooling water within the circulation path 10 is detected by the temperature sensor 9, and this detecting signal is sent out to a control unit 1. Fuel cell temperature and a circulating water temperature have a correlation, and although it is an equivalent for outside air temperature at the time of starting as shown in drawing 4, it goes up gradually with a generation of electrical energy. Although constant temperature is maintained if regular, it is this limitation neither at the time of a high power generation of electrical energy, nor a transient.

[0027] It is necessary to send in a lot of cooling water to a heat exchanger 6 to fully reduce a circulating water temperature, and the load of a circulating pump 3 will become so big. Since it can be managed with the amount of low discharge flow at the time of the low water temperature which does not need cooling of cooling water on the contrary, a pump load is low. Thus, a circulating water temperature and a pump load have correlation, and if pump capacity is insufficient, a circulating water temperature cannot be reduced. It is not desirable to improve pump capacity using a large-sized pump in the fuel cell system for mobiles with much constraint to loading in which the pump drive by the external power is impossible.

[0028] So, with this operation gestalt, a cooling demand and a conductivity reduction demand are made compatible within the limits of the pump capacity restricted by adding amendment by the temperature of cooling water to the bypass flow rate to the conductivity reduction equipment 4 determined according to the conductivity of cooling water, and attaining optimization. As shown in drawing 5 , by reducing the cooling water bypass rate to conductivity reduction equipment 4 at the time of the large high water temperature of a pump load, abolish the pressure loss in the filter section as much as possible, a pump load is made to mitigate, and, specifically, priority is given to cooling of cooling water. Moreover, at the time of low water temperature with few pump loads, the bypass rate of conductivity reduction equipment 4 HE is increased, and the ion concentration of pure water is reduced. It enables this it not only can to perform miniaturization of a circulating pump 3, and power-saving, but to plan the improvement in the engine performance of a fuel cell 2, low-pricing of

a cooling system including a heat exchanger 6, and the optimum design of conductivity reduction equipment 4.

[0029] You may make it amend the cooling water bypass rate to the conductivity reduction equipment 4 determined according to the conductivity of cooling water as 2nd operation gestalt about control of the cooling water bypass rate to conductivity reduction equipment 4 according to the load of a circulating pump 3. As shown in drawing 6, since the load of a circulating pump 3 has the rotational frequency and correlation, loaded condition can be judged from the rotational frequency of a circulating pump 3. When this pump load is large, a bypass rate is reduced, and when a pump load is small, it controls so that a bypass rate increases. Since conductivity reduction processing of cooling water is performed by this when there are few pump loads, the demand maximum load of a circulating pump 3 can be pressed down, and the miniaturization can be attained.

[0030] By the way, when priority is given to cooling of cooling water and the by-pass rate to conductivity reduction equipment 4 is reduced, any reach the conductivity which a fuel cell 2 does not permit depending on the operational status or the environmental condition of a fuel cell 2, and have a possibility of causing the fall of performance-traverse ability, and failure of a fuel cell 2 by the fall of the amount of generations of electrical energy. Then, as shown in drawing 7, when conductivity exceeds the upper limit defined beforehand, it is good by operating an electro-magnetic valve 7 and making all cooling water HEBAIPASU conductivity reduction equipment 4 to plan so that priority may be given to reduction of conductivity irrespective of a circulating water temperature or a pump load. Furthermore, as shown in drawing 8, when decline in conductivity cannot be prevented but conductivity has risen across the tolerance of a fuel cell 2, while suspending the generation of electrical energy by the fuel cell 2, in addition, it is desirable to stop a circulating pump 3 and to stop supply of the cooling water to a fuel cell 2.

[0031] The operation gestalt which judged degradation of conductivity reduction equipment 4 to drawing 9 is shown. Conductivity reduction equipment 4 has the filter structure where it filled up with ion exchange resin as mentioned above. Since conductive ion is adsorbed chemically and it has become constructing, there is a limitation in the amount of adsorption, and ion exchange resin needs periodical exchange. Since it was difficult to judge the degradation of ion exchange resin externally, it should exchange for every fixed period conventionally. However, since an exchange stage is not time amount and should call at the adsorption limitation of ion essentially, it was difficult to find out the optimal exchange stage.

[0032] So, with this operation gestalt, as shown in drawing 9 , while measuring the conductivity of the cooling water before conductivity reduction equipment 4 passage by 1st conductivity sensor 8A, the conductivity of the cooling water which passed conductivity reduction equipment 4 is measured by 2nd conductivity sensor 8B. The configuration of the part of others of drawing 9 is the same as that of drawing 1 , gives the same sign to the same part, and is shown.

[0033] When conductivity reduction equipment 4 is functioning normally, the conductivity of the passed cooling water should be falling. On the other hand, if conductivity is not falling also after passing conductivity reduction equipment 4, conductivity reduction equipment 4 will not function normally. That is, the measured value by 2nd sensor 8B should be falling rather than the measured value by 1st sensor 8A. Thus, the degradation of conductivity reduction equipment 4 can be judged by comparing the signal of 1st conductivity sensor 8A with the signal of 2nd conductivity sensor 8B, and detecting the fall width of face of conductivity. The time of the fall width of face of the conductivity used as the decision criterion at this time when the conductivity by 1st sensor 8A is higher is larger, and it is [the time] good for the lower time to make it small. It is because the adsorption effectiveness by ion exchange resin also falls when the conductivity of cooling water is low.

[0034] Thus, if an inclination is emitted with a control unit 1 and exchange of ion exchange resin is urged when the degradation judging of conductivity reduction equipment 4 is performed and it is judged as degradation, the function of conductivity reduction equipment 4 can always be maintained at normal, and the conductivity of fuel cell cooling water can be managed more appropriately.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The outline block diagram of the operation gestalt of the fuel cell equipment which applied this invention.
[Drawing 2] The outline block diagram of conductivity reduction equipment.
[Drawing 3] The property Fig. showing the relation between conductivity and the cooling water bypass rate to conductivity reduction equipment.
[Drawing 4] The property Fig. showing the relation between the busy condition of a fuel cell, and a circulating water temperature.
[Drawing 5] The property Fig. showing the relation between the conductivity according to a circulating water temperature, and the cooling water bypass rate to conductivity reduction equipment.
[Drawing 6] The property Fig. showing the relation between the rotational frequency of a circulating pump, and a load.
[Drawing 7] The property Fig. about the upper limit of conductivity.
[Drawing 8] The property Fig. about the allowed value of conductivity.
[Drawing 9] The outline block diagram of other operation gestalten of the fuel cell equipment which applied this invention.
[Description of Notations]
1 Control Unit
2 Fuel Cell
3 Circulating Pump
4 Conductivity Reduction Equipment
5 Tank
6 Heat Exchanger
7 Electro-magnetic Valve
8 Conductivity Sensor
8a Conductivity sensor
8b Conductivity sensor
9 Temperature Sensor
10 Circulating Flow Way
11 Bypass Passage
12 Ion Exchange Resin

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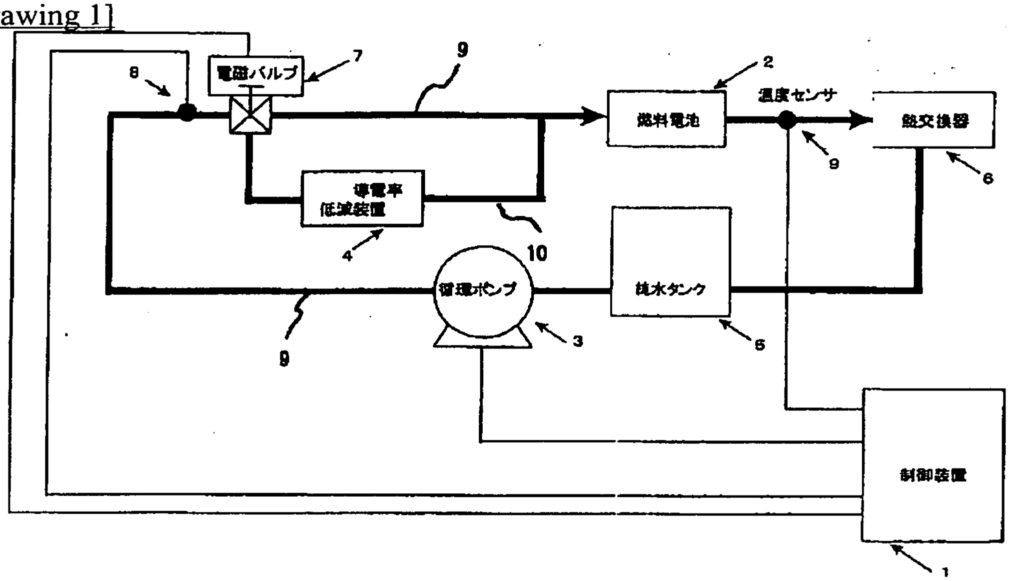
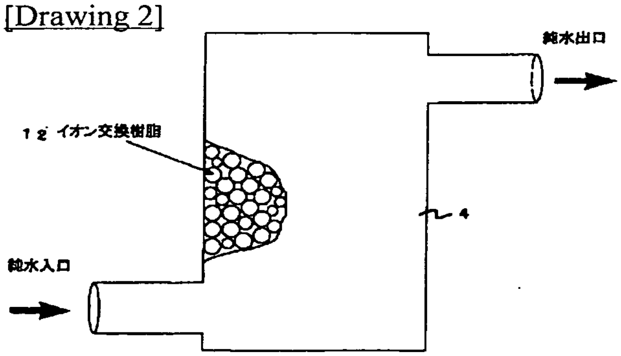
DRAWINGS

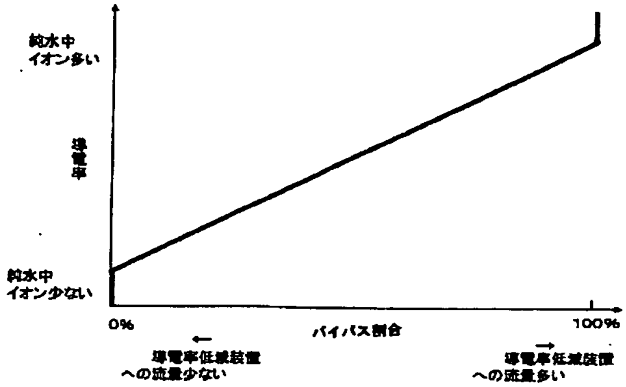
[Drawing 1]



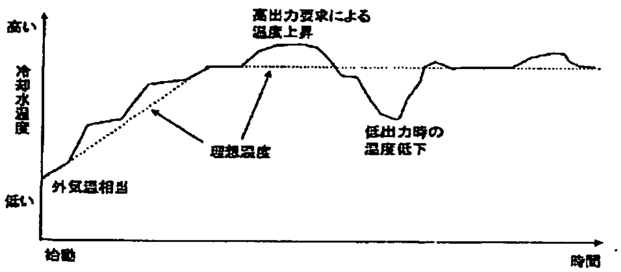
[Drawing 2]



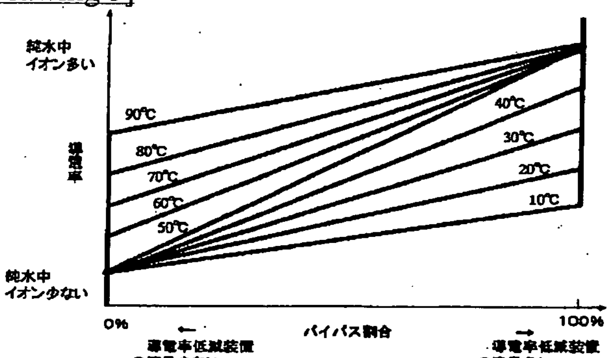
[Drawing 3]



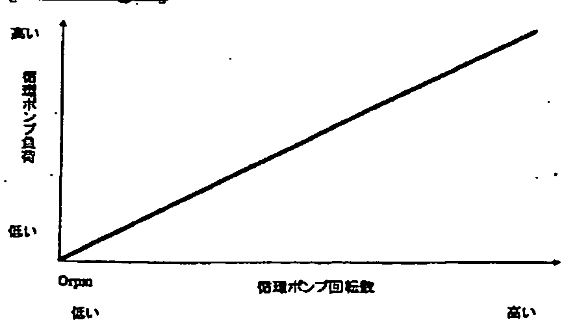
[Drawing 4]



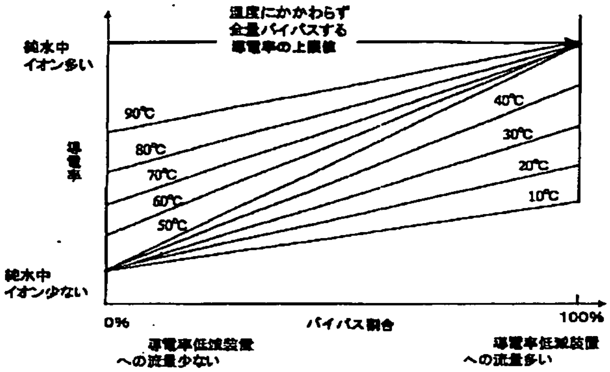
[Drawing 5]



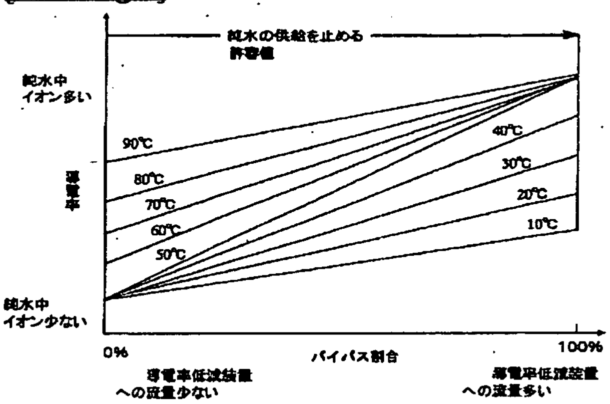
[Drawing 6]



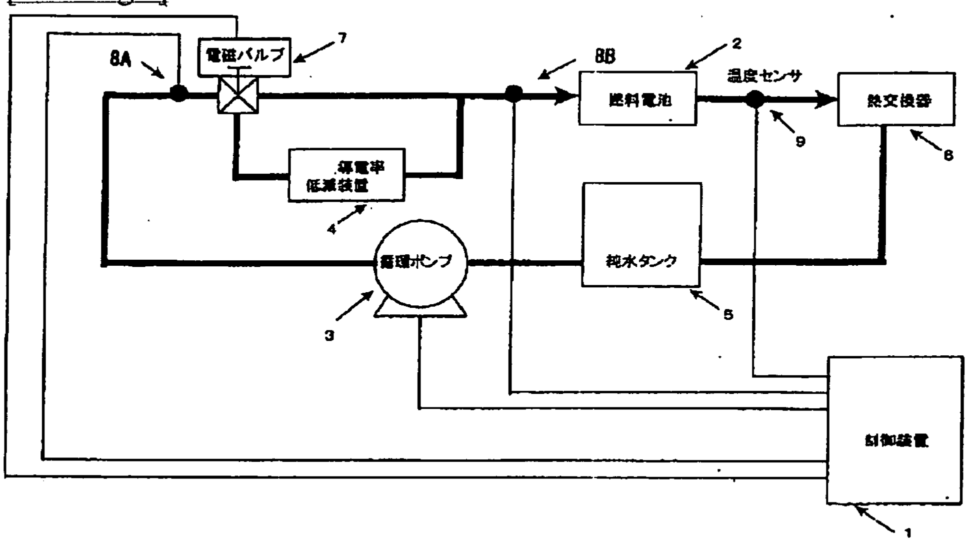
[Drawing 7]



[Drawing 8]



[Drawing 9]



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